



## **Swiss teleradiology survey: present situation and future trends**

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**Abstract:** The purpose of this study was to obtain a survey about the present situation including the usage pattern, technical characteristics and the anticipated future of teleradiology in Switzerland. An internet-based questionnaire was made available to all members of the Swiss Society of Radiology. Questions concerning current teleradiology usage, the type of transmitted modalities, the technology employed, security, billing issues and the anticipated future of teleradiology were addressed. One hundred and two (22.67%) of 450 radiologists responded to the survey. Of the total, 41.2% (42) were teleradiology users, 35.3% (36) planned to use teleradiology in the near future and 24.5% (25) did not use or plan to use teleradiology. The mean number of examinations transmitted per month was 198 (range 1-2,000) and the mean distance was 33km (range 1,250km). An emergency service was considered the most important purpose (mean score 6.90; minimum 1, maximum 10) for the use of teleradiology, followed by image distribution (mean 6.74) and expert consultation (mean 6.61). The most commonly transmitted modality was computed tomography (mean 8.80), followed by conventional X-rays (8.40) and magnetic resonance imaging (8.32). The most commonly transmitted format was Digital Imaging and Communications in Medicine (DICOM) (66.7%), followed by bitmap/Joint Photographic Experts Group (jpg) (38.1%), using the DICOM send/receive protocol (52.4%), followed by the hypertext transfer protocol (26.2%) and e-mail (21.4%). For security a secure connection (54.8%) followed by encryption (14.3%) and anonymization (9.5%) was used. For the future, image distribution was rated the most important aspect of teleradiology (7.88), followed by emergency (7.22) and expert consultation (6.53). Development of legal regulations is considered most important (8.17), followed by data security guidelines (8.15). Most radiologists believe that insurance companies should pay for the costs of teleradiology (37.3%), followed by the radiologist (33.3%). In conclusion, in Switzerland a wide spectrum of teleradiology applications and technologies is in use. Guidelines and reimbursement issues remain to be solved

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**Abstract** The purpose of this study was to obtain a survey about the present situation including the usage pattern, technical characteristics and the anticipated future of teleradiology in Switzerland. An internet-based questionnaire was made available to all members of the Swiss Society of Radiology. Questions concerning current teleradiology usage, the type of transmitted modalities, the technology employed, security, billing issues and the anticipated future of teleradiology were addressed. One hundred and two (22.67%) of 450 radiologists responded to the survey. Of the total, 41.2% (42) were teleradiology users, 35.3% (36) planned to use teleradiology in the near future and 24.5% (25) did not use or plan to use teleradiology. The mean number of examinations transmitted per month was 198 (range 1–2,000) and the mean distance was 33 km (range 1,250 km). An emergency service was considered the most important purpose (mean score 6.90; minimum 1, maximum 10) for the use of teleradiology, followed by image distribution (mean 6.74) and expert consultation (mean 6.61). The most commonly transmitted modality was computed tomography (mean 8.80), followed by conventional X-rays (8.40) and magnetic resonance imag-

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**Keywords** Teleradiology · Picture archiving and communication system · Radiology and radiologists, socioeconomic issues · Emergency radiology

## Introduction

Teleradiology is the most widely practiced form of telemedicine [1, 2]. Teleradiology is typically defined as the electronic transmission of radiological images from one location to another for interpretation and/or consultation. Teleradiology is used to provide an efficient service, to increase productivity and to improve coverage especially for emergency departments [3–5]. Digital imaging and developments in computer technology and telecommunications mean that the “filmless” radiology department is becoming the standard in industrialized countries [6]. Picture archiving and communication systems (PACS) are being installed in all major imaging centers. However, exchange of digitally available imaging data is often not possible because of the lack of integration of the different systems. Although the Digital Imaging and Communications in Medicine (DICOM) format is widely accepted, the limiting technical factor is often the communication link between two sites. Furthermore, ethicolegal implications and data security of this technology, both nationally and internationally, remain an issue [7].

The purpose of this study was to obtain a survey about the present situation, including the usage pattern and the technical characteristics as well as the anticipated future of teleradiology in Switzerland.

## Materials and methods

An internet-based questionnaire was made available to all members of the Swiss Society of Radiology. A total of 450 radiologists were contacted by e-mail and asked to complete this survey. Questions concerning the current state and the anticipated future of teleradiology in Switzerland were asked.

### Teleradiology in Switzerland: usage pattern

The radiologists were asked if they were using teleradiology actively at the present time, if they were planning to use teleradiology in the future or if they did not use or intend to use teleradiology at all. The radiologists had to rate the most important purpose for using teleradiology: emergency (for example, reading emergency examination from sites without 24-h coverage by a qualified radiologist); image distribution (transferring examination to referring physicians or other health care providers involved in the treatment of the patient); expert consultation (reading of examinations by an expert such as subspecialized radiologist, for example, a pediatric radiologist or a neuroradiologist, or a specialized clinician, such as a surgeon specializing in neurotrauma); education (teleradiological real-time demonstration examinations for rounds, teleradiology-based teaching for students and residents). The importance of te-

leradiological transfer of images was also rated according to the imaging modality: conventional X-rays, ultrasound, computed tomography (CT), MRI and nuclear medicine studies.

### Technical characteristics

The radiologists were asked about the mean number of examinations transmitted per month and the mean distance for transmission. Technical specifications such as the image data format [DICOM, bitmap format, such as the Joint Photographic Experts Group (jpg) format [8], Portable Document Format (pdf)], the transmission protocol [DICOM send/receive, file transfer protocol (ftp), hypertext transfer protocol (http), e-mail], the type of connection for transmission [peer-to-peer connection, secured wide-area network (WAN), such as a state/canton net, standard internet connection, an internet connection with a virtual private network (VPN), the Swiss Health Info net (HIN), which is run by the Swiss Medical Association FMH and provides secure servers to the members of the Association as well as other providers of health care services (<http://www.hin.ch>)], security measures (secured connection, anonymization of examinations or encryption of data) and the kind of transmission of radiology reports [transmission by fax, by e-mail, or by direct connection to the radiology information system (RIS) or the electronic patient record (EPR)] had to be specified.

### Opinion about the future of teleradiology

The radiologists were asked which use (emergency radiology, image distribution, expert consultation or education) of teleradiology was considered most important in the future and which regulations/guidelines for the proper use of teleradiology would be necessary for the future (state regulations for teleradiology, guidelines for data security in teleradiology, guidelines for quality assurance in teleradiology, guidelines for data storage or other guidelines). The radiologists were asked about the need for nationwide integration of teleradiology and how integration should be implemented (development of a standard interface for all teleradiology users, a nationwide PACS server where all imaging studies are stored or a national medical network).

### Data analysis and statistics

In questions with multiple possible answers the radiologists were asked to rate the items from the most important or the most appropriate to the least important or the least appropriate. Subsequently the items were scored on a linear scale from 1 to 10: the most important was scored with ten points; the least important with one point. Mean score

values and standard deviations were calculated for each item. To compare the opinion about the future of teleradiology between users and nonusers an unpaired two-tailed *t* test was used. A *p* value of less than 0.05 was considered significant.

## Results

One hundred and two (22.67%) of 450 radiologists responded to the survey. Of the total, 41.2% (42) were teleradiology users, 35.3% (36) planned to use teleradiology in the near future and 24.5% (25) did not currently use teleradiology and did not intend to use teleradiology in the future. Table 1 summarizes the distribution of teleradiology users between urban and rural areas, indicating a far larger proportion of users or future users in urban areas.

### Purpose for using teleradiology

Table 2 summarizes the ratings and the ranks of the most common uses of teleradiology and the imaging modality for which teleradiology was the most important. Currently, an emergency service was the most important purpose (mean score 6.90; minimum 1, maximum 10) for using teleradiology, followed by image distribution (mean 6.74) and expert consultation (mean 6.61). CT was considered to be the most relevant type of imaging (8.80), followed by conventional X-rays (8.40) and MRI (8.32).

### Technical characteristics

Table 3 displays the technical details of teleradiology applications in Switzerland. The mean number of examinations transmitted per month was 198 (range 1–2,000) and the mean distance was 33.66 km (range 1–250 km). The most commonly transmitted format was DICOM (66.7%), followed by bitmap format/jpg (38.1%). The DICOM send/receive protocol (52.4%) was most frequently used, followed by http (26.2%) and e-mail (21.4%). For security a secured connection (54.8%) was used in most installations, followed by encryption (14.3%) and anonymization (9.5%).

**Table 1** Proportion of teleradiology users in urban and rural areas

	Urban (%)	Number	Rural (%)	Number
Teleradiology in use	37	30	55	11
Planned in near future	37	30	30	6
Teleradiology not used	26	21	15	3
Total	100	81	100	20

**Table 2** The ratings and ranks of the most common uses of teleradiology and the imaging modality

	Rank	Mean <sup>a</sup>	SD
Most important purpose to use teleradiology in the present situation			
Emergency	1	6.90	3.64
Image distribution	2	6.74	3.88
Expert opinion	3	6.61	3.48
Education	4	3.81	3.16
Most important transmitted imaging modality in the present situation			
CT	1	8.80	1.38
Conventional X-rays	2	8.40	1.74
MRI	3	8.32	2.46
US	4	6.67	1.75
Nuclear medicine	5	6.29	1.63

SD standard deviation, CT computed tomography, US ultrasound

<sup>a</sup>Mean score (minimum 1, maximum 10)

**Table 3** Technical details of teleradiology services in Switzerland

	Rank	Percentage	Number
Transmitted format			
DICOM	1	66.7	28
Bitmap (jpg)	2	38.1	16
Other	3	4.8	2
pdf	4	2.4	1
Transmission protocol			
DICOM send/receive	1	52.4	22
http	2	26.2	11
e-mail	3	21.4	9
ftp	4	14.3	6
Transmission concept			
Push data	1	69.0	29
Pull data	2	38.1	16
Connection type			
Internet	1	33.3	14
Secured WAN	2	26.2	11
Internet with VPN	3	19.0	8
Peer to peer	4	16.7	7
Internet health net	5	7.1	3
Other	6	7.1	3
Security			
Secured connection	1	54.8	23
Data encryption	2	14.3	6
Anonymization	3	9.5	4
Transmission of report			
Fax	1	76.2	32
RIS/MIS	2	21.4	9
e-mail	3	19.0	8

The total varies according to number of answers received  
 DICOM Digital Imaging and Communications in Medicine, *jpg* Joint Photographic Experts Group, *pdf* Portable Document Format, *VPN* virtual private network, *RIS* radiology information system, *MIS* medical information system

**Table 4** Future trends

Table 4	Future trends	All			User			Nonuser			<i>p</i> *
		Rank	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	

	Which is the most important purpose for teleradiology in the future?										
	Distribution	1	7.88	2.73	1	8.13	2.56	1	7.72	2.85	0.49
	Emergency	2	7.22	2.77	2	7.70	2.73	2	6.86	2.78	0.16
	Expert consultation	3	6.53	2.09	3	6.21	1.63	3	6.74	2.33	0.24
	Education	4	4.27	2.20	4	3.95	2.32	4	4.46	2.14	0.31
	Which regulations/guidelines need to be developed?										
	Legal	1	8.17	2.34	2	8.05	2.36	1	8.28	2.33	0.66
	Data security	2	8.15	2.21	1	8.11	1.97	2	8.18	2.38	0.87
	Other	3	7.20	3.36	3	6.67	4.16	3	7.33	3.34	0.77
	Quality	4	6.67	2.42	4	6.54	2.16	4	6.74	2.58	0.74
	Storage	5	5.73	2.19	5	5.00	2.21	5	6.23	2.06	0.02
	Is nationwide teleradiology integration necessary?										
	National medical net	1	7.43	2.61	2	7.41	2.59	1	7.44	2.65	0.97
PACS picture archiving and communication system	Standard interface	2	7.39	2.61	1	7.59	2.36	2	7.23	2.81	0.59
	National PACS	3	7.01	2.43	3	7.00	2.31	3	7.02	2.55	0.97
	Not necessary	4	6.11	3.44	4	6.25	3.69	4	5.98	3.29	0.78

\*Unpaired *t* test significance (two-tailed)

PACS picture archiving and communication system  
 \*Unpaired *t* test significance (two-tailed)

### Opinion about the future of teleradiology

Tables 4 and 5 summarize the opinion of Swiss radiologists about the future of teleradiology. For the future, image distribution was considered to be the most important aspect of teleradiology (7.88), followed by emergency (7.22) and expert consultation (6.53). Regulations concerning legal aspects of teleradiology were considered most important as future activities of radiological societies and government agencies (8.17), followed by data security guidelines (8.15). Current nonusers of teleradiology rate the importance of guidelines for data storage significantly higher than users ( $p=0.02$ ). Current teleradiology users believe that nationwide integration should be preferably implemented by the development of a standard interface. Current nonusers believe in the advantage of a nationwide medical net. Most radiologists state that insurance companies should pay for the costs of teleradiology (37.3%), followed by the radiologist (33.3%).

**Table 5** Financing teleradiology services

	Rank	Percentage	Number
Teleradiology services should be billed		85.9	73
To health insurance company	1	37.3	38
To radiologist performing imaging	2	33.3	34
To patient	3	23.5	24
To referring physician	4	20.6	21

### Discussion

An increasing number of PACS systems are being installed. PACS is the basis of teleradiology. Currently sold systems commonly have implemented important teleradiological features and permit simultaneous consultations on different sites and almost instant reporting from specialist radiologists. The Integrating the Healthcare Enterprise (IHE) initiative promotes the use of standards for communication between computer systems in radiology and the rest of the hospital and beyond [9]. In radiology, communication between imaging modalities and other functions, such as printing, image display and storage, has benefited significantly from the DICOM standards. Beyond the radiology department, medical information systems commonly use health level 7 (HL7) as a communication standard [10]. The main applications of teleradiology are to provide radiological expertise at remote sites more quickly than would otherwise be possible, to provide emergency services [11] and to provide access to subspecialty advice or second opinions [4].

In Switzerland, a wide spectrum of applications of teleradiology is in use. Similar to a large German survey, an emergency teleradiology service is the most important purpose of teleradiology [12, 13]. Electronic image distribution is increasingly important in a filmless environment [14]. A Norwegian study has found that teleradiology has an important role in improving interhospital management of patients with head injuries [15]. Education and research seems to be a less important aspect of teleradiology at present. Teleradiology is increasingly used in the USA—for overnight coverage of imaging services. The technical feasibility of international teleradiology has been demonstrat-



ed for CT cases in the USA and daily routine transmission to a satellite reading facility in India [16, 17].

CT is the most important transmitted modality in teleradiology. An increasing number of CT scanners are installed in smaller hospitals without a radiologists on duty 24 h a day. Teleradiology has been shown to be effective and cost-efficient for emergency cranial CT in a study by Stranzinger et al. [11] in central Switzerland.

The DICOM format and the DICOM send/receive protocol is clearly the most widely used format for transmission of teleradiology data. However, the technical characteristics of teleradiology applications in Switzerland show a large diversity. One of the main reasons relates to the fact that vendor-specific DICOM protocol additions are commonly required to realize teleradiology solutions. New concepts rely on vendor-independent standard protocols without specific additions, such as DICOM e-mail published in DICOM supplement 54 that defines a connection between the internet and the medical communication inside hospitals [18, 19]. Server-based distribution is already widely used for image distribution to referring physicians [14]. Web-based teleradiology management systems have been developed for patient transfers from one facility to another transferring images from PACS to PACS [20].

Many countries have developed guidelines for the use of teleradiology [21–25]. However, laws and regulations governing the practice of medicine and data security were commonly enacted before the recent developments in sophisticated technology. In Switzerland, there are limited practice guidelines and regulations relating specifically to telemedicine or teleradiology, while the USA state legislation tends to focus primarily on responsibility and accountability issues, with licensure being seen as the gold standard for competence to practice. Swiss radiologists feel that the development of regulations is one of the most

important tasks for the future. Data security guidelines and quality assurance need to be addressed as well [26, 27].

Pressure mounts for more cost-effective services in medicine. Teleradiology may contribute to a cost-effective health care system [28]. Faster and more competent decisions, fewer patient transfers and reduced mail and film costs may be the benefit [5, 29, 30]. However, the implementation of a teleradiology service requires a significant capital investment and maintenance costs. The question of who pays for the costs of teleradiology needs to be addressed. For simple image distribution, the question may be answered [31]. Film costs and costs for postage and packing are high and usually these costs are covered by the imaging facility. These costs will be replaced by the costs of the teleradiology service, which may be considerably lower compared with the costs of sending hardcopies by mail. It is far less evident, however, who will pay for the costs for expert consultations or emergency teleradiology. There is no uniform opinion among Swiss radiologists. Insurance companies are reluctant in accepting to pay for additional services. Usually reimbursement covers the imaging and the radiologist report. However, costs for teleradiology and a second reading by an expert are not covered in the new pay scale (TARMED) for the Swiss health care system.

An important limitation of this survey is the return rate of 23% of all Swiss radiologists. The numbers presented in this study are therefore only valid for this group of radiologists. The estimated values for all Swiss radiologists may therefore range from the values presented in this study to one fifth of these values. However, in comparison with the return rates for other surveys, the return rate in our study is considerably higher [12].

In conclusion, in Switzerland a wide spectrum of teleradiology applications and technologies is in use. Guidelines and reimbursement issues remain to be solved.

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